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Short-Term Outcomes After Robotic-Assisted Total Mesorectal Excision for Rectal Cancer

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Background: Laparoscopic total mesorectal excision for rectal cancer remains a difficult procedure with high conversion rates. We have sought to improve on some of the pitfalls of laparoscopy by using the DaVinci robotic system. Here we report our two-year experience with robotic-assisted laparoscopic surgery for primary rectal cancer.

Methods: A prospectively maintained database of all rectal cancer cases starting in November 2004 was created. A series of 39 consecutive unselected patients with primary rectal cancer was analyzed. Clinical and pathologic outcomes were reviewed retrospectively.

Results: 22 patients had low anterior, 11 intersphincteric and six abdominoperineal resections. Postoperative mortality and morbidity were % and 12.8%, respectively. The median operative time was 285 minutes (range 180–540 mins). The conversion rate was 2.6%. A total mesorectal excision with negative circumferential and distal margins was accomplished in all patients, and a median of 13 (range 7–28) lymph nodes was removed. The anastomotic leak rate was 12.1%. The median hospital stay was 4 days. There have been no local recurrences at a median follow-up of 13 months.

Conclusions: Robotic-assisted surgery for rectal cancer can be carried out safely and according to oncological principles. This approach shows promising short-term outcomes and may facilitate the adoption of minimally invasive rectal surgery.

Key Words: Total mesorectal excision—Minimally invasive surgery—Robotic-assisted—Rectal cancer.

During the last decade minimally invasive surgery has influenced the approach used in a variety of operations, and its use and indications continue to expand. Numerous studies have shown that laparoscopic colectomy for cancer results in superior short-term results and equivalent oncological outcomes when compared with open surgery.[1–3] Similarly, multiple trials including a variety of randomized studies,[3–5] prospective nonrandomized studies[6–10] and a recent meta-analysis[11] have shown that laparoscopic rectal resection results in superior postoperative outcomes compared with open surgery. In addition, lymph node harvest, margins, local recurrence and survival appear to be similar in patients subjected to laparoscopic versus open proctectomy.[3,4,6–12] However, there is little doubt that laparoscopic total mesorectal excision (TME) is technically very challenging and the learning curve for this procedure is longer and more demanding than for laparoscopic colectomy. Conversion rates as high as 34% were reported in the British CLASSIC trial, a large prospective randomized study comparing laparoscopic to open colorectal surgery.[3]

In recent years robotic-assisted laparoscopic surgery has been advocated to improve vision, dexterity

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and comfort of the surgeon. This technique is especially suited for dissection in confined spaces requiring precise movements and fine tissue dissection, such as in the pelvis.[13] Not surprisingly, robotic surgery has had a dramatic impact in prostate surgery with over 30,000 robotic assisted radical prostatectomies completed worldwide in the last few years.[14]

We have employed robotic surgery for total mesorectal excisions since 2004, and have previously described our first six robotic TME cases and compared them with six cases carried out with conventional laparoscopy.[15] Our initial experience suggested that robotic rectal surgery results in superior comfort for the surgeon and possibly an easier mesorectal dissection. In the present study we report our cumulative experience with robotic surgery for rectal cancer in a series of 39 consecutive unselected procedures performed at our institution.

PATIENTS AND METHODS

All patients who present to our institution with newly diagnosed rectal cancer are offered minimally invasive resection with robotic-assisted TME. We do not have any contraindication for this approach except tumors invading adjacent structures (T4 cancers) requiring en bloc multi-organ resections. Clinicopathological data are entered into a prospective database, and patients are followed closely postoperatively. For this study we analyzed our first 39 consecutive patients with primary rectal cancer who underwent robotic-assisted resections between November 2004 and April 2007. Rectal cancer was defined as any tumors within 15 cm of the anal verge. Our practice is to stage all rectal cancer with endoscopic ultrasound. However, some patients without ultrasound evaluation are referred to us after neoadjuvant therapy carried out at outside facilities and thus accurate preoperative staging of these patients is not possible. This study was approved by the institutional review board of our institution.

Surgical Technique

Our preference is to perform a hybrid technique with laparoscopic mobilization of the colon and robotic-assisted proctectomy with total mesorectal excision. In short, one 12-mm camera port, three 8-mm robotic working ports and three additional laparascopic trochars are placed (Fig. 1). The patient is kept in a steep Trendelenburg position during the whole procedure in order to help remove the small bowel from the pelvis. A medial-to-lateral dissection with high ligation of the inferior mesenteric vein and artery near its origin is carried out laparoscopically followed by laparoscopic mobilization of the splenic flexure, descending and sigmoid colon. Thereafter the DaVinci robotic system is brought into the field and docked to the previously placed ports. The two working arms usually carry a grasper on the left connected to bipolar cautery, and a hook with monopolar cautery on the right. The third robotic arm on the patient's left side carries another grasper and is used as an additional tool for retraction as needed. The assistant is placed on the right side of the patient and uses two ports for suctioning and additional retraction. The dissection is continued in the fashion of a total mesorectal excision as previously described.[15] Once the TME is completed the distal rectum is divided by the assistant using a reticulating 30-mm linear stapler through the 12-mm laparoscopic port. The specimen is extracted through a 4-cm minilaparotomy. An end-to-end anastomosis is then created using a circular stapler. In cases of very low tumors, an intersphincteric resection with specimen extraction through the anus and hand sewn coloanal anastomosis is performed. It is our preference to divert our patients with a temporary loop-ileostomy. Abdominoperineal resections (APR) are performed

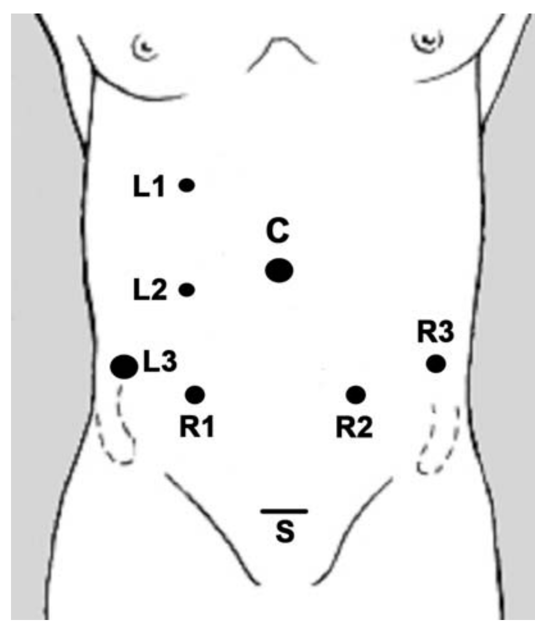

FIG. 1. Localization and size of trocars. The two working robotic ports (R1, R2) must be placed 12–14 cm from the symphysis in the midclavicular line. R1–R3, 8-mm robotic ports; L1–L2, 5-mm laparoscopic ports; L3, 12-mm laparoscopic port; C, camera port; S, symphysis.

in cases of sphincter-invading lesions or patient preference.

RESULTS

A total of 39 patients underwent robotic-assisted laparoscopic rectal resection with total mesorectal excision for primary rectal cancer. Patient clinicopathologic data are listed in Table 1. The majority of tumors were located in the lower or middle rectum (< 11 cm from anal verge). Preoperative staging by computer tomography was carried out in all patients. In 21 patients preoperative endoscopic ultrasound was available.

Table 2 describes operative details. The median operative time was 285 minutes (180–540) with a median robotic TME time of 60 minutes (range 35–135 minutes). The docking of the DaVinci robot took approximately 20 minutes. In all cases a total mesorectal excision with autonomic nerve preservation could be achieved. Pathological results are listed in Table 3. One patient with stage IV disease had a single lung metastasis, and a simultaneous lung wedge resection was carried out. All circumferential and distal margins were negative, and the median number of removed lymph nodes was 13. In our cohort, six patients treated with neoadjuvant chemoradiation had a complete response with no remaining tumor cells at the primary site or in the mesorectum. In three patients, there was no tumor identified in the rectal wall, but positive lymph nodes were found in the mesorectum.

Nasogastric tubes were removed directly after surgery. The median time to start of a clear liquid diet was two days, with 36% of patients starting their diet on postoperative day 1 and 28% on postoperative day 2. The median length of stay was four days.

At a median follow up time of 13 months (2–29) there have been no local recurrences. However, four patients have developed distant metastatic disease. We did not encounter any 30-day or cancer-related mortality. One patient died four months after surgery of unrelated causes.

Complications

One patient experienced severe hemorrhage after injury of a pelvic vein during an APR. This was not a consequence of the robotic portion of the operation but of the perineal dissection. The same patient developed postoperative bladder dysfunction and dehiscence of the perineal wound. A total of four patients experienced anastomotic leaks (12.1% leak rate) in our series, two with a coloanal anastomosis and two after low anterior resection. These four patients required reoperations. One patient underwent a laparotomy with drainage and creation of a diverting loop-ileostomy. The remaining three patients were managed with a combination of laparoscopic and transanal drainage, as diverting ileostomies had been placed during the initial surgeries. In all of these four patients, the ileostomies were taken down and intestinal continuity was re-established after sufficient healing time. There was only one conversion in this

TABLE 1. *Baseline characteristics of patients (n = 39)*

Variable	Number of patients (%)
Gender	18F, 21M
Age[a] (years)	58 (26–84)
ASA score III–IV:	17 (43.6%)
Body mass index[a] (kg/m^2)	26 (16–44)
Tumor location	
Lower rectum (< 7cm)	21 (53.9)
Middle rectum (7–11cm)	16 (41)
Upper rectum (> 11cm)	2 (5.1)
Previous abdominal surgery	14 (35.9)
Preoperative chemoradiation therapy	33 (84.6)

[a] Median values (range) expressed
F, female; M, male

TABLE 2. *Perioperative data*

Operative details	Number of patients (%)
Type of resection	
Low anterior resection	22 (56.4)
Coloanal anastomosis	11 (28.2)
APR	6 (15.4)
Operative time (min)[a]	285 (180–540)
TME time (min)[a]	60 (35–135)
Estimated blood loss (ml)[a]	200 (25–6000)
Time to clear liquid diet (days)[a]	2 (1–11)
Length of stay (days)[a]	4 (2–22)

[a] Median value (range) expressed

TABLE 3. *Histopathological data*

Variable	
(y)TNM stage[a]	Number of patients (%)
0	8 (20.5)
I	13 (33.3)
II	4 (10.3)
III	13 (33.3)
IV	1 (2.6)
Number of removed lymph nodes[b]	13 (7–28)
Distal margin (cm)[b]	2.65 (0.4–7.5)
Positive circumferential margin	None

[a] 6th edition of the AJCC TNM classification
[b] Median (range)

TABLE 4. *30-day morbidity and mortality*

Complication	Number of patients (%)
Intraoperative bleeding > 1000 ml	1 (2.6)
Anastomotic leakage[a]	4 (12.1)
Reoperation	4 (10.3)
Wound infection	2 (5.1)
Urinary disorder	1 (2.6)
Postoperative ileus (> 6 days)	5 (12.8)
Others (atrial fibrillation, parotitis)	2 (5.1)
Total major complications	5 (12.8)
Mortality	0

[a] Out of 33 patients with anastomosis

series (conversion rate 2.6 %). This occurred in a patient with a body mass index (BMI) of 44 kg/m^2 requiring a coloanal anastomosis for a low tumor. This same patient developed one of the four anastomotic leaks. 30-day mortality and morbidity data are listed in Table 4.

DISCUSSION

The technique of total mesorectal excision (TME) has become standard of care for treatment of cancer of the middle and distal rectum with the lowest recurrence rates (5% local recurrence at five years) published in literature.[16] TME includes the routine excision of the intact mesorectum by precise sharp dissection in the areolar tissue between the visceral and parietal layers of the pelvic fascia.[16] It is a difficult and time-consuming procedure laparoscopically as well as open, and carries a substantial morbidity. In recent years, laparoscopic TME has been proven to be a safe and feasible procedure in experienced hands.[3–12]

Major pitfalls of laparoscopic rectal surgery are the technical and anatomic complexity in the narrow pelvis, resulting in a steep learning curve and high conversion rates. Some maneuvers are difficult to perform because of the limited dexterity of nonarticulating instruments, unnatural hand–eye coordination and loss of three-dimensional (3D) vision. Robotic technology has been developed to obviate some of the limitations of conventional laparoscopic surgery.[13,17,18] Early experiences with different robotic-assisted colorectal procedures such as colectomies, anterior rectal resections, and rectopexy are described in the recent literature.[15,19–23] This current study describes the short-term outcomes of 39 consecutive rectal cancer cases performed at a single institution. To our knowledge this is the largest series of unselected robotic-assisted rectal resection for malignancy in the literature.

We found that telerobotic surgery facilitates several aspects of the pelvic dissection and mobilization of the rectum. One of the main advantages of the robotic system is the surgeon-controlled, stable camera with stereoscopic vision allowing a perfectly still view of the operative field.[13,17] In addition, the surgeon operates as if standing above the head of the patient, thus having equal access to both right and left pelvic side walls. Multi-articulated instruments allow for a variety of angles of attack, facilitating a sharp dissection around the contour of the rectum and mesorectum. The robotic handles transfer the hand movements of the surgeon to the tip of the instruments offering a comfortable, ergonomically ideal operating position.[17,18] In our assessment, the operative surgeon experienced less physical strain and fatigue at the end of the case, a benefit that has been described by other authors as well.[18,19,22]

Because of the features described above, robotic surgery actually requires the same skill set used during open surgery and thus the learning curve at the console is relatively short even for laparoscopically inexperienced surgeons.[23] This has also been described in the urologic literature, where a laparoscopic naive yet experienced open surgeon transferred open surgical skills to a laparoscopic environment in 12 robotic cases with outcomes comparable to those of a skilled laparoscopic surgeon after more than a hundred laparoscopic radical prostatectomies.[24] Our high success rate in completing the total mesorectal excision and the low conversion rate may reflect these advantages of the robotic system. We feel that the learning curve is faster, but further studies are necessary to prove this possible benefit in rectal surgery.

Nevertheless there are some drawbacks to current robotic systems. The present generation of the DaVinci systems does not provide tensile feedback, so that the surgeon must rely on visual cues to estimate the tension exerted on tissue. Thus great care must be taken when handling bowel in order to avoid traumatic injuries. The system requires precise positioning of the robot for optimal operative outcome and to avoid robotic arm collision. The position of the patient cannot be changed without undocking the robotic arms. We experienced that correct port setup is the key to a successful procedure. Our patients were placed in a steep Trendelenburg position during the entire case. The robot was brought in between the legs of the patient. The two working robotic ports need to be placed 12–14 cm from the symphysis along the midclavicular line to reach the pelvic floor (Fig. 1). To eliminate the need for repositioning of the robot we choose to mobilize the splenic flexure and descending colon laparoscopically and use the robot for the TME part only. This hybrid approach saves the time for repetitive robotic setups. The actual TME itself only took an average of 60 minutes. Operative times for laparoscopic rectal surgery have been reported between 88–600 minutes, with no reference to the length of the actual total mesorectal excision.[4,6,7] Our patients experienced a very fast recovery with a median time to diet of 1.5 days and a median hospital stay of only four days. This is consistent with the faster recovery noted after laparoscopic TME compared with open surgery.[10,11]

Our results demonstrate that the robotic TME can be carried out safely with a high success rate and following oncological principles. We had no positive circumferential or distal margins, no rectal perforation and a median number of 13 removed lymph nodes. Our data does not support the theory that laparoscopic TME may result in a higher incidence of positive circumferential margins, a concern expressed in the CLASSIC trial, which found a small and not statistically significant increase in positive radial margins in the laparoscopic TME group compared with open surgery (12% vs. 6 %).[3] Other large comparative series have not found an increase in positive margins with the laparoscopic approach.[9,25] Our leak rate of 12.1% is comparable to the 6-16% rate reported in open series[16,26,27] and 13–19% in laparoscopic series.[6–10] The single most important risk factor for leakage is the height of the anastomosis from the anal verge.[26] Ninety-five per cent of our patients had low to middle rectal cancer requiring an anastomosis within 5 cm of the anal verge. Morino et al. noticed a slightly higher incidence of anastomotic leaks in their comparative study of laparoscopic and open TME (13.5 vs. 5%), a finding which did not reach statistical significance.[10] It is possible that difficulties with stapling the distal rectum and the relatively easier mobilization of the rectum down to the levator plane with consequent low anastomosis may contribute to a higher percentage of anastomotic fistulas after laparoscopic TME.

Our series has demonstrated a very low conversion rate. Hartley et al.[9] reported a conversion rate of 33% and the CLASSIC trial encountered a 34% rate in their rectal group with other studies reporting conversion rates between 3–23%.[3,4,6–10,12] Advanced local cancer stage, bulky tumors, and high body mass index appeared to be the main reason for conversions in these studies. We feel that obesity and male sex may be important factors influencing the need for conversion. Our single conversion was in a morbidly obese man with abundant mesorectal and pelvic fat in a narrow pelvis, thus rendering the dissection very difficult. Recent literature suggests that patients who experience conversion have worse short- and possibly long-term outcomes compared to laparoscopic and even open cases.[28] In the randomized prospective CLASSIC trial, patients who were converted to open surgery experienced a higher rate of perioperative morbidity (up to 93%) than either the open or laparoscopic surgery arms.[3] Thus, means to decrease the chances of conversion in laparoscopic colorectal operations are highly desirable.

This series demonstrates that robotic surgery for rectal cancer is safe and feasible. This approach results in a quick return of bowel function and short hospital stay. Rectal cancer surgeons without extensive laparoscopic colorectal experience who wish to transition from open to minimally invasive TME may benefit from this modality. Future studies are necessary to determine the long-term oncological outcomes of robotic-assisted total mesorectal excision.

REFERENCES

1. Veldkamp R, Gholghesaei M, Bonjer HJ, et al. Laparoscopic resection of colon cancer. Consensus of the European Association of Endoscopic Surgery (E.A.E.S). *Surg Endosc* 2004; 18:1163–85.
2. The Clinical Outcomes of Surgical Therapy Study Group A comparison of laparoscopically assisted and open colectomy for colon cancer. *N Engl J Med* 2004; 350:2050–9.
3. Guillou PJ, Quirke P, Thorpe H, et al. MRC CLASICC trial group. Short-term endpoints of conventional versus laparoscopic-assisted surgery in patients with colorectal cancer (MRC CLASICC trial): multicenter, randomised controlled trial. *Lancet* 2005; 365:1718–26.
4. Leung KL, Kwok SP, Lam SC, et al. Laparoscopic resection of rectosigmoid carcinoma: prospective randomised trial. *Lancet* 2004; 363:1187–92.
5. Zhou ZG, Hu M, Li Y, et al. Laparoscopic vs. open total mesorectal excision with anal sphincter preservation for low rectal cancer. *Surg Endosc* 2004; 18:1211–5.
6. Morino M, Parini U, Giraudo G, Salval M, Contul RB, Garrone C. Laparoscopic total mesorectal excision: a consecutive series of 100 patients. *Ann Surg* 2003; 237:335–42.
7. Leroy J, Jamali F, Forbes L, et al. Laparoscopic total mesorectal excision (TME) for rectal cancer surgery: long-term outcomes. *Surg Endosc* 2004; 18:281–9.
8. Barlehner E, Benhidjeb T, Anders S, Schicke B. Laparoscopic resection for rectal cancer: outcomes in 194 patients and review of the literature. *Surg Endosc* 2005; 19:757–66.
9. Hartley JE, Mehigan BJ, Qureshi AE, Duthie GS, Lee PW, Monson JR. Total mesorectal excision: assessment of the laparoscopic approach. *Dis Colon Rectum* 2001; 44:315–21.
10. Morino M, Allaix ME, Giraudo G, Corno F, Garrone C. Laparoscopic versus open surgery for extraperitoneal rectal cancer: a prospective comparative study. *Surg Endosc* 2005; 19:1460–7.
11. Aziz O, Constantinides V, Tekkis PP, et al. Laparoscopic versus open surgery for rectal cancer: a meta-analysis. *Ann Surg Oncol* 2006; 13:413–24.

12. Bretagnol F, Lelong B, Laurent C, et al. The oncological safety of laparoscopic total mesorectal excision with sphincter preservation for rectal carcinoma. *Surg Endosc* 2005; 19:892–6.
13. Lanfranco AR, Castellanos AE, Desai JP, Meyers WC. Robotic surgery: a current perspective. *Ann Surg* 2004; 239:14–21.
14. Patel VR, Chammas MF Jr, Shah S. Robotic assisted laparoscopic radical prostatectomy: a review of the current state of affairs. *Int J Clin Pract* 2007; 61:309–14.
15. Pigazzi A, Ellenhorn JD, Ballantyne GH, Paz IB. Robotic-assisted laparoscopic low anterior resection with total mesorectal excision for rectal cancer. *Surg Endosc* 2006; 20:1521–5.
16. Heald RJ, Moran BJ, Ryall RD, Sexton R, MacFarlane JK. Rectal cancer: the Basingstoke experience of total mesorectal excision, 1978–1997. *Arch Surg* 1998; 133:894–9.
17. Ballantyne GH, Moll F. The da Vinci telerobotic surgical system: the virtual operative field and telepresence surgery. *Surg Clin North Am* 2003; 83:1293–1304.
18. Stylopoulos N, Rattner D. Robotics and ergonomics. *Surg Clin North Am* 2003; 83:1321–37.
19. D'Annibale A, Morpurgo E, Fiscon V, et al. Robotic and laparoscopic surgery for treatment of colorectal diseases. *Dis Colon Rectum* 2004; 47:2162–8.
20. Rockall TA, Darzi A. Robot-assisted laparoscopic colorectal surgery. *Surg Clin North Am* 2003; 83:1463–8.
21. Munz Y, Moorthy K, Kudchadkar R, et al. Robotic assisted rectopexy. *Am J Surg* 2004; 187:88–92.
22. Rawlings AL, Woodland JH, Crawford DL. Telerobotic surgery for right and sigmoid colectomies: 30 consecutive cases. *Surg Endosc* 2006; 20:1713–8.
23. Giulianotti PC, Coratti A, Angelini M, et al. Robotics in general surgery: personal experience in a large community hospital. *Arch Surg* 2003; 138:777–84.
24. Ahlering TE, Skarecky D, Lee D, Clayman RV. Successful transfer of open surgical skills to a laparoscopic environment using a robotic interface: initial experience with laparoscopic radical prostatectomy. *J Urol* 2003; 170:1738–41.
25. Tsang WW, Chung CC, Kwog SY, Li MK. Laparoscopic sphincter-preserving total mesorectal excision with colonic J-pouch reconstruction: five-year results. *Ann Surg* 2006; 243:35–38.
26. Morgan BJ, Heald RJ. Risk factors for, and management of anastomotic leakage in rectal surgery. *Colorectal Dis* 2001; 3:135–7.
27. Carlsen E, Schlichting E, Guldvog I, Johnson E, Heald RJ. Effect of the introduction of total mesorectal excision for the treatment of rectal cancer. *Br J Surg* 1998; 85:526–9.
28. Moloo H, Mamazza J, Poulin EC, et al. Laparoscopic resections for colorectal cancer: Does conversion affect survival?. *Surg Endosc* 2004; 18:732–5.